Understanding Porometer versus AOS Testing of a Geotextile

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This technical note focuses on the use of ASTM D6767 Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Test versus ASTM D4751Test Method for Determining Apparent Opening Size of a Geotextile.

The current industry standard for measuring a geotextile's particle retention characteristics is ASTM D4751 (AOS). ASTM D4751 Test Method for Determining Apparent Opening Size of a Geotextile shows one attribute for the potential filtration capability in a geotextile and does accurately characterize the pore spaces. TenCate Geosynthetics has begun the effort to establish a different method for determining the pore size of a geotextile (voids). This work will provide the engineer with the data to select the correct geotextile to meet their filtration and soil requirements using ASTM D6767 Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Test.

How do the tests differ?

ASTM D4751Test Method for Determining Apparent Opening Size (AOS) measures the largest apparent pore diameter in a geotextile. The test is performed by cutting five 8" diameter samples of material, placing the samples securely into metal sieves, and adding 50 grams of calibrated glass beads of known diameter on top of the material. The sieves are mechanically shaken for ten minutes to induce particle movement through the geotextile. After each swatch is shaken, the beads that passed through the geotextiles are weighed. The process is repeated with decreasing glass bead diameters until the AOS of the sample is determined. The AOS is defined by O_{95} which indicates the approximate largest particle that would pass through the geotextile.

The AOS testing method provides only one opening size value; a pore size distribution cannot be obtained. While this test is not completely destructive, setting the fabric in the sieve can lead to inaccurate results due to distortion of the sample from over handling. The test does not have the ability to distinguish between material defects such as a larger hole that does not reflect the properties of the material or the product characteristics.

The most obvious issue encountered in the AOS test is the high probability of smaller sized test beads passing through larger sized openings in the fabric, rather than passing through the openings that are the same size as the specific test bead diameter. Other AOS testing problems include electrostatic effects, testing beads sticking together, and beads becoming trapped in the material from friction. With so many potential problems with the AOS test method, an improved test must be developed. The Capillary flow porometer is just such a test that provides a great deal of geotextile opening size information accurately and precisely.

ASTM D6767 Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Test is a test method in which a wetting liquid is allowed to saturate the pores of the geotextile test sample followed by a non-reacting gas displacing the liquid from the geotextile pores. To perform the test, a geotextile sample is cut into a 1.5 in^2 area and placed into the chamber of the test device. The porometer forces air through the dry sample, taking measurements at different valve position increments (cc/min or l/min) and at varying pressures (psi). When the maximum predetermined pressure or flow rate is reached, the testing device resets, readying for the second phase of the test. The sample is saturated with a wetting agent with a known surface tension and subjected to another series of pressure and flow rate measurements. The raw data from these measurements are run through a series of calculations to determine the minimum, maximum and mean pore size, filter flow percentage (comparable to permeability; can be used to calculate retention values such as O_{95}), and pore size distribution.

What does Porometer testing provide? The Porometer test method is not limited to one opening size and will measure opening values between O_0 and O_{98}. Each test has a range opening sizes which are reported as an average for a sample. One would have to run countless AOS tests to provide the same amount of information provided from *one* porometer test, but the test comparison is impractical because the AOS test only measures O_{95}. Using the values obtained for the Porometer testing of the geotextile, one can accurately predict the way the material will perform during both AOS testing and water flow testing (ASTM D4491). The Porometer test method is more accurate and defines a material's drainage and filtration characteristics. The porometer will let one know if there are any pores larger than the O_{95}, such as O_{98}, while AOS testing will report the O_{98} falsely as the O_{95} value.

Utilizing porometer test data generated in 2010/2011 for HP370, HP570 and RS580i, the AOS and Water Flow for these products could be predicted. Table 1 indicates RS580i has larger pore openings there are fewer large pore openings compared to HP370 and HP570. RS580i has a uniform pore distribution within the 30µm - 250µm range which attributes to RS580i higher flow rate.

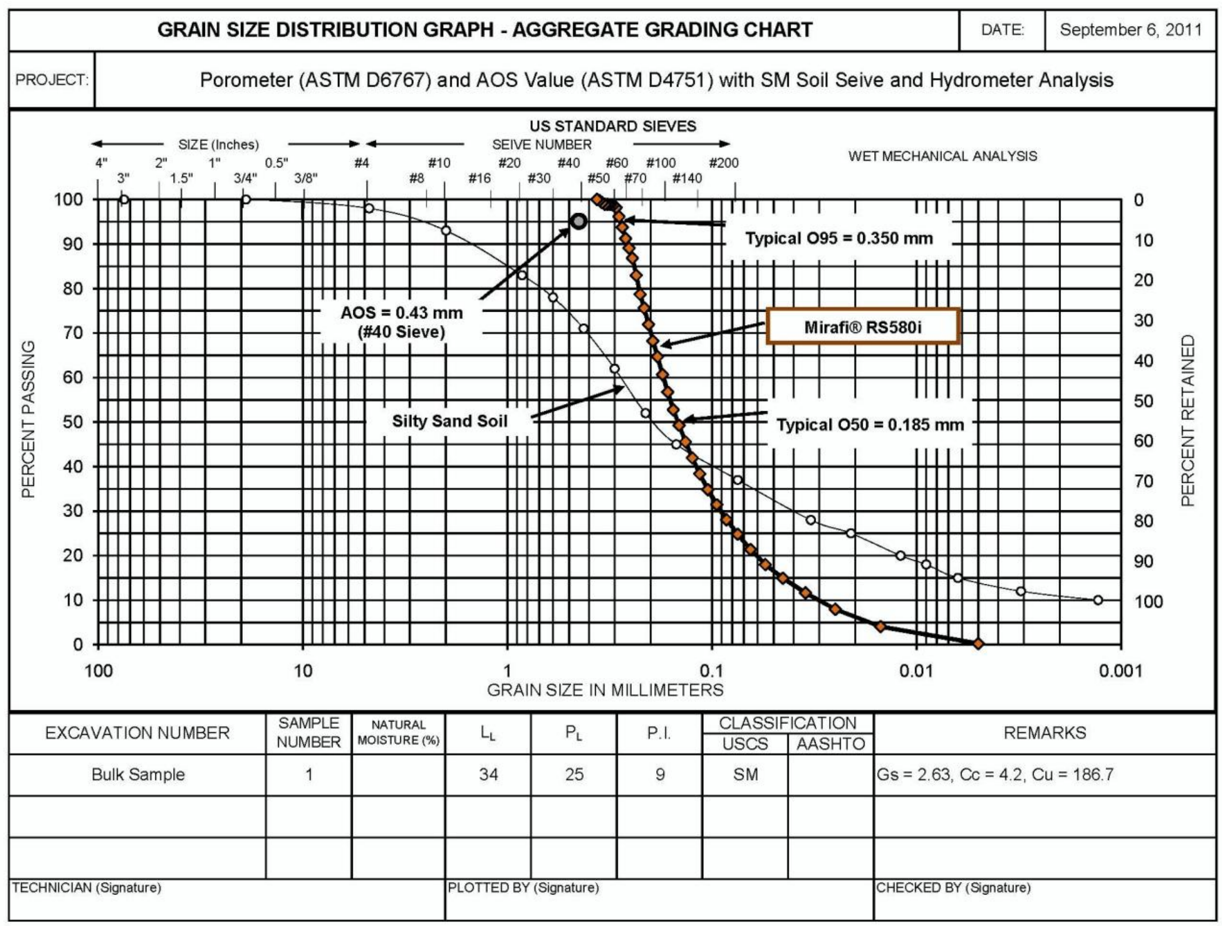
Table 1

	Pore Size O50 ASTM D6767 microns	Pore Size O95 ASTM D6767 microns	Water Flow ASTM D4491 gpm/ft²	AOS ASTM D4751 US Sieve	Pore Distribution ASTM D6767 30 µm - 250 µm
RS580I	185	350	100	50	2.96
HP370	165	325	55	40	6.86
HP570	185	355	50	40	12.6

All values are typical

The ability for Porometer test to predict a geotextiles results from AOS and Water Flow testing is an indication of the Porometer test's ability to predict a geotextile's soil retention ability and permeability requirements in the field. While the AOS does have an application for use in geotextile manufacturing QC/QA testing, Porometer testing provides much more in-depth information about a geotextile without suffering from the limited information and testing problems resulting from using the AOS test.

A graphical representation of the data obtained from both Porometer testing and AOS testing on Mirafi® RS580i is shown in Figure 1. The typical pore size distribution curve for RS580i can be related to its filtration capacity for a candidate soil much more accurately than a single AOS value. TenCate Geosynthetics is currently developing soil filtration guidance that will utilize the pore size distributions of our geotextiles determined from Porometer testing.



EXCAVATION NUMBER	SAMPLE NUMBER	NATURAL MOISTURE (%)	L_L	P_L	P.I.	CLASSIFICATION USCS	CLASSIFICATION AASHTO	REMARKS
Bulk Sample	1		34	25	9	SM		Gs = 2.63, Cc = 4.2, Cu = 186.7
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Figure 1. Pore size distribution and AOS value of Mirafi® RS580i compared to a silty sand (SM) soil grain size distribution.

Appendix A
ASTM D4751Test Method for Determining Apparent Opening Size of a Geotextile versus ASTM D6767 Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Test

<table>
<tr><th>Apparent Opening Size of a Geotextile</th><th>Pore Size Characteristics of Geotextiles by Capillary Flow Test</th></tr>
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Test method: ASTM D4751

Summary of Procedure:

- Material to be tested is cut to size *(approximately 10” in diameter*) to fit into a sieve pan.
- Sample is then securely mounted inside the sieve pan. 50 grams of glass beads of a known size are placed on top of the sample.
- Sieve pan is then covered and placed in sieve shaker and shaken for 10 minutes.
- The glass beads that pass through the fabric are then collected from below the fabric and weighed.
- For a material to obtain a “pass” result for a given bead size, no more than 5% of the original 50 grams of beads may pass through the fabric.
- Each bead size must be tested individually on a given material. For example, if a material allows 20% of 70 sieve beads pass, then it should be tested for a 60 sieve. It would pass for a 60 sieve, if less than 5% of the 60 sieve beads pass.
- Sieve bead sizes/diameter cross reference

Sieve number	Diameter (mm)
20	0.85
30	0.60
40	0.425
50	0.30
70	0.212
100	0.15

Comments: AOS test essentially determines the largest single opening size in a fabric; if there is one very large hole, relative to the “normal” holes found in the fabric, then the results could be skewed as all the glass beads will pass through this one large hole.

AOS test is subject to testing inconsistencies; i.e., operator error in sample preparation, etc., distortion of yarns/fibers in sample to be tested.

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Test method: ASTM D6767

Summary of Procedure:

- Test conducted using a device called a *capillary flow porometer.*
- Material to be tested is cut to size (about 1” in diameter) and saturated with a liquid of known surface tension.
- It is placed into a sealed chamber in the promoter so that air only flows *through* the material and not escape around the edges.
- Air is forced toward the sample at increasing pressure until the largest pore opens under the pressure. This is also called the *bubble point opening size* because when the largest pore opens, the first bubble of saturation liquid from the sample is formed.
- Test continues by incrementally increasing the pressure until *all* pores in the sample are opened.
- Each pressure is recorded by the porometer. From this pressure data and surface tension of the liquid, each opening size is calculated using Darcy’s law and this calculation assumes spherical shape pore.
- The test results provide graphical distribution of all pore sizes i.e., illustrates if there are many small pores/few large pores, etc.
- Also provides numerical values for largest pore (bubble point pore) diameter and mean pore diameter.

Comments: Pore size test determines size of all pores within a sample. From that data, the mean and largest pore size diameter are calculated, along with a distribution chart of pore sizes, illustrating the range of pore sizes and relative number.

Pore size test is less susceptible to operator error, and is much more repeatable from test to test. Data is presented in graphical and tabular form as computer generated documents.

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